

ATTACHMENT F: EMERGENCY AND REMEDIAL RESPONSE PLAN

Facility Name: FutureGen 2.0 Morgan County CO₂ Storage Site
IL-137-6A-0002 (Well #2)

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Location of Injection Well: Morgan County, IL; 26–16N–9W; 39.800266°N and 90.07469°W

This Emergency and Remedial Response Plan (ERRP) describes actions the permittee (the FutureGen Alliance) will take at the FutureGen 2.0 Morgan County CO₂ storage site in the unlikely event of an emergency that could endanger any underground source of drinking water (USDW) within the project Area of Review (AoR) during construction, operation or post-injection site care. Such events may include unplanned CO₂ release or detection of unexpected movement of CO₂ or associated fluids in or from the injection zone. This plan demonstrates how the FutureGen Alliance will comply with 40 CFR 146.94.

If information from the FutureGen 2.0 monitoring network (described in the Testing and Monitoring Plan) indicates that injected CO₂ and/or associated fluid migration or pressures have occurred which could endanger a USDW, the FutureGen Alliance will take the following actions:

1. Cease injection according to the procedures in the Class VI permit and close down the injection wells.
2. Perform appropriate steps to identify and characterize the source and cause of the adverse incident that has the potential to endanger a USDW or release CO₂.
3. Notify the U.S. Environmental Protection Agency (EPA) Underground Injection Control (UIC) Program Director of the adverse incident within 24 hours.
4. Implement necessary remedial actions, including those outlined in this Emergency Response and Remediation Plan

Part 1: Resources or Infrastructure Potentially Affected

Four USDW aquifer zones are located in the AoR, ranging from the deep St. Peter Sandstone (approximately 2,000 ft above the top of the injection zone) to the surficial aquifer system approximately 3,700 ft above the injection zone. The surficial aquifer system is a significant groundwater resource within the AoR. Response actions to CO₂ or saline migration into a USDW would vary according to the aquifer. It should be noted that the leak would be detected and response actions would be conducted in the lowermost USDW—St. Peter Sandstone—far in advance before shallower USDWs would be affected unless a leak were to occur along an injection well or deep monitoring well.

The land is used primarily for agriculture. Residences and farm-related buildings are scattered across the land surface, particularly along roads. Surface-water features such as creeks, streams,

and impoundments formed by small earthen dams are also present in the area. Limited stretches of woodland parallel stretches of streams. Most of the land surface is farmland. Shallow (<100ft bgs) groundwater-supply wells are associated with residences. The injection site will eventually have a pipeline and some small buildings. Figure 1 shows the surface water features within the AoR for this project. Figure 2 shows additional surface features in the survey area.

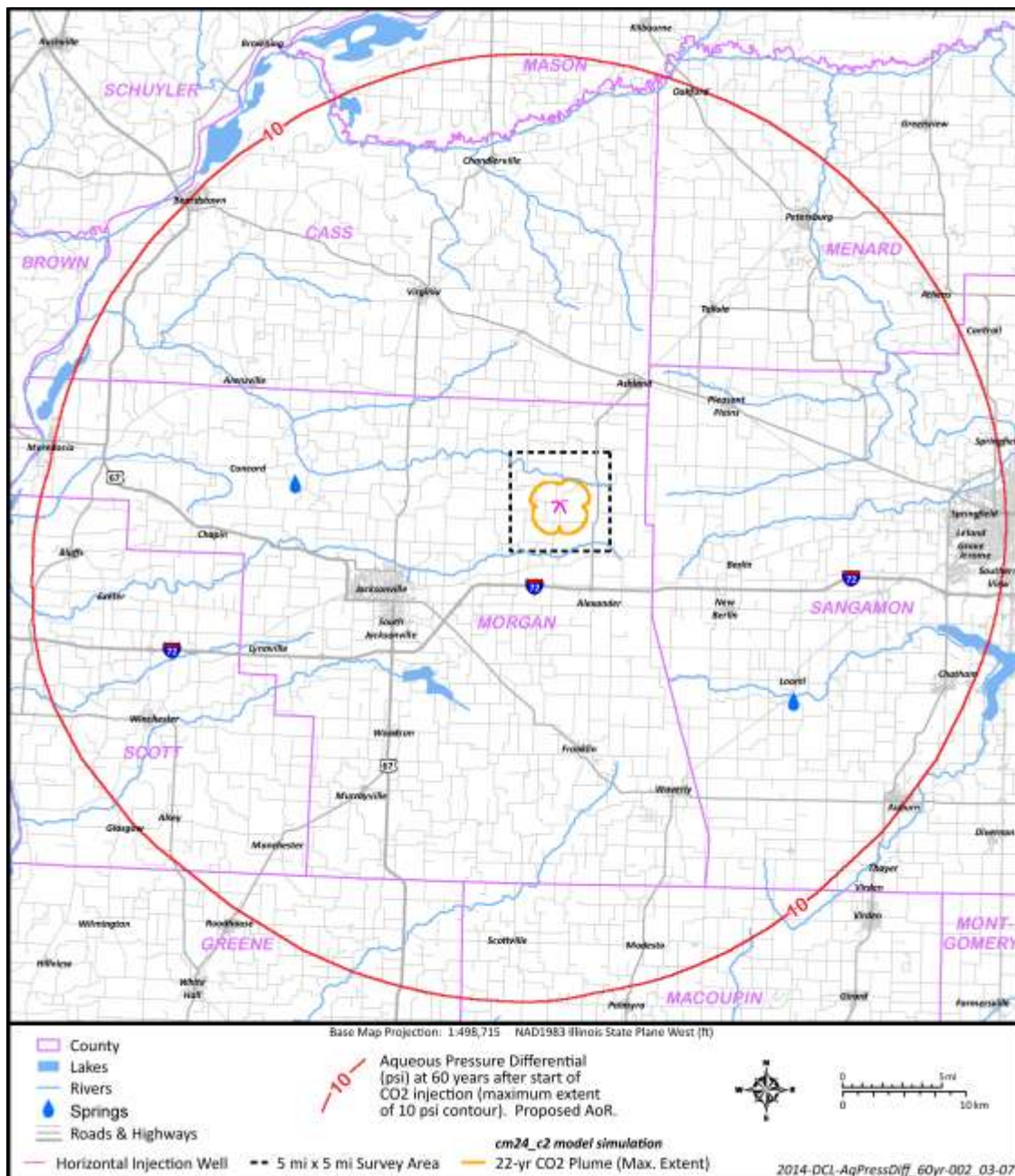


Figure 1. Map of Surface-Water Features within the Area of Review.

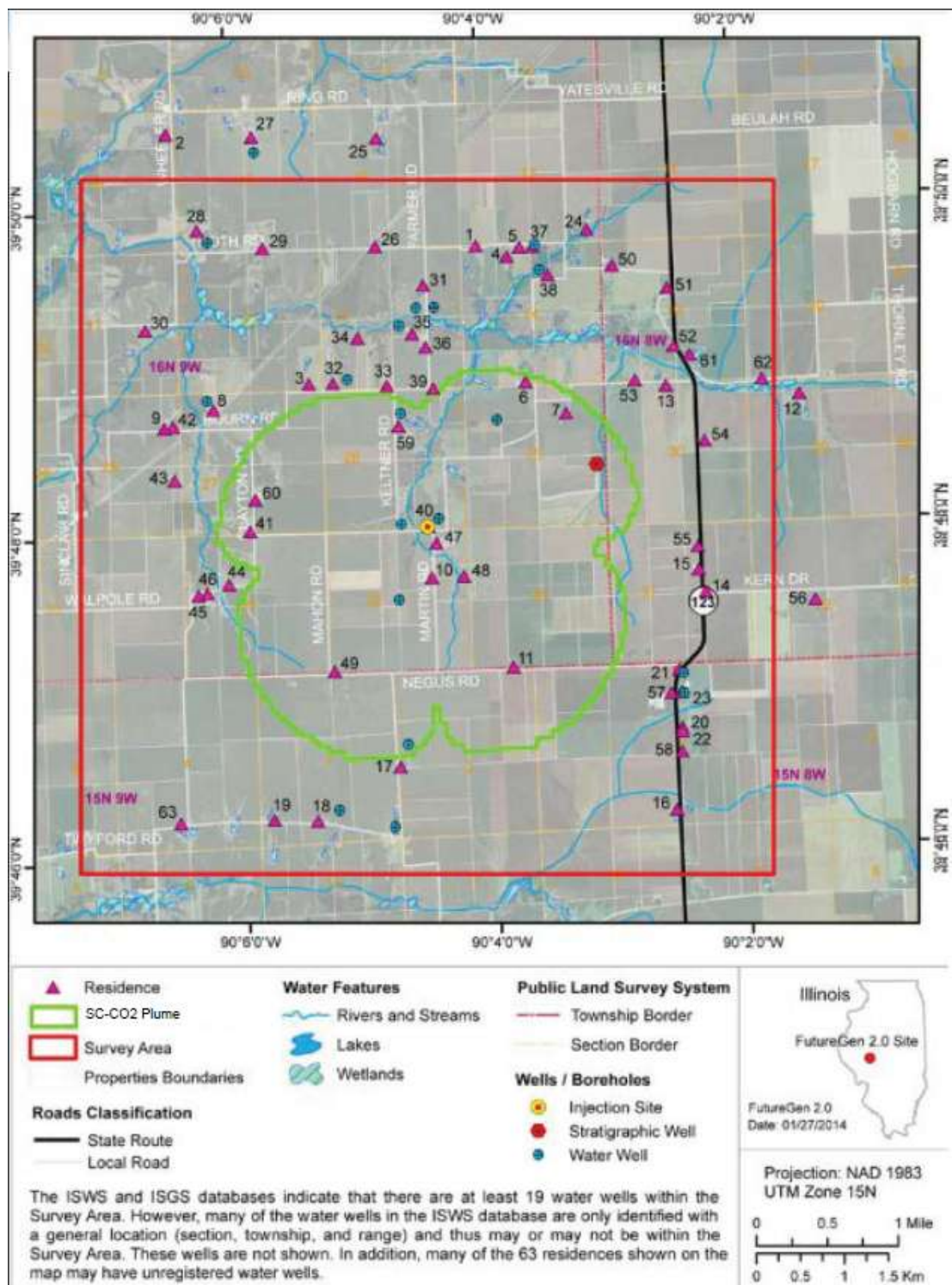


Figure 2. Map of Survey Area including Residences, Water Wells, and Surface-Water Features above the predicted extent of the CO₂ plume after 22 years.

Part 2: Identification of Adverse Incidents

The possible adverse incident scenarios identified in Table 1 consist of both slow and sudden releases of CO₂ or brine. Such releases will result in the implementation of emergency or remedial actions as described in Part 3 (of this plan). It should be noted that the worst-case consequences of various scenarios are developed to ensure that response plans are in place for all eventualities.

Table 1 lists the types of potential adverse incidents that will trigger response actions to protect USDWs if the incidents occur during the construction, injection, and post-injection site-care periods. The activities that the FutureGen Alliance will undertake in response to these incidents are described in Part 3 (of this plan).

Table 1. Potential Adverse Incidents	
Construction Period	<ul style="list-style-type: none">• Over-pressurized natural gas (blow out)• Movement of brine between formations during drilling
Injection Period	<ul style="list-style-type: none">• Loss of mechanical integrity (injection or monitoring wells)• Rapid and/or unexpected movement of CO₂ outside defined AoR• Migration of CO₂ from injection zone through faults and fractures• Migration of CO₂ from injection zone through undocumented wells• Migration of CO₂ from injection zone through failure of the confining zone (loss of containment)• Monitoring equipment failure or malfunction• Movement of brine or CO₂ from injection zone to overlying USDW• Natural disaster (such as severe weather)• Seismic event
Post-Injection Site-Care Period	<ul style="list-style-type: none">• Loss of mechanical integrity (monitoring wells)• Rapid and/or unexpected movement of CO₂ outside defined AoR• Migration of CO₂ from injection zone through faults and fractures• Migration of CO₂ from injection zone through undocumented wells• Migration of CO₂ from injection zone through failure of the confining zone (loss of containment)• Monitoring equipment failure or malfunction• Movement of brine or CO₂ from injection zone to overlying USDW• Natural disaster (such as severe weather)• Seismic event

Remedial response actions implemented at the FutureGen 2.0 site will be proportional to the severity of the condition triggering the emergency actions. The severity of the emergency condition are categorized as major, serious, or minor as defined in Table 2.

Table 2. Definition of the Severity of Adverse Incidents	
Consequence Degree of Severity	Definition
HIGH (Major Emergency)	Known release or indication of a potential incident which poses an immediate (acute) risk to human health, resources, or infrastructure. Response actions involving local authorities (evacuation, isolation of areas, or restrictions on water usage) should be initiated. Example: well blowout during injection.
MEDIUM (Serious Emergency)	Incidents/releases posing potential (chronic) risk to human health, resources, or infrastructure if conditions worsen or no (mitigative/remedial) response actions are taken. Examples: well seal failures, detection of increased pressure or indicators of CO ₂ in zones above caprock.
LOW (Minor Emergency)	Incident poses a challenge to confinement barrier but does not result in the immediate release of CO ₂ or brine posing a risk to human health, resources or infrastructure. Example: higher than anticipated pressure in monitoring wells.

Part 3: Emergency Identification and Response Actions to Protect USDWs

This arrangement of responses is conceptual; the severity of an adverse incident will determine the actual response(s) deployed and will be executed following notification of, and in consultation with, the UIC Program Director. If any adverse incident has the potential to endanger a USDW, the FutureGen Alliance will notify the UIC Program Director within 24 hours. After the implementation of actions taken to address the emergency, the FutureGen Alliance will demonstrate the efficacy of the remedial response actions to the satisfaction of the UIC Program Director before resuming injection operations. Injection operations will resume when authorized by the UIC Program Director after having established that all requirements have been met.

Where the phrase “initiate shutdown plan” is used, the following protocol will be employed: the FutureGen Alliance will immediately cease injection and will notify the power plant that it is not currently injecting CO₂.

If an adverse incident occurs, the FutureGen Alliance will deploy a variety of emergency or remedial responses depending on the circumstances (e.g., the location, type, and volume of a release) to protect USDWs. Any unanticipated incident or condition observed to pose a threat to groundwater, surface water, infrastructure, or people will be treated as an adverse incident (“emergency”). Response actions will depend upon the severity of the adverse incident, as defined in Table 2. This part of the ERRP summarize the types of adverse incidents that could occur and the likely sequence of responses that would be undertaken to protect USDWs during construction, injection, and post-injection site care. Emergency and remedial responses will be considered in a sequence of progressively more extensive actions corresponding to the degree of severity. The list for each adverse incident is ordered accordingly.

ADVERSE INCIDENTS POTENTIALLY AFFECTING USDWS: CONSTRUCTION PERIOD

Event/Description: Over-pressurized fluid (blowout): This event could occur during well drilling, if a pocket of high pressure gas or fluid is encountered resulting in a sudden release.

Severity: High

Time of Event: Drilling

Avoidance Measures: Care in drilling; use and maintain blow out preventer at wellhead; control drilling fluid density.

Detection Methods: Well pressure, annulus pressure monitoring. Drilling fluid (mud) return flow and density, pressure.

Potential Response Actions: Specific response will depend on the type of well (injection or monitoring). In general, the following will be undertaken:

- Stop drilling.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Verify proper and complete operation of blowout preventer hardware.
- Inject heavy fluid to regain hydrostatic control.
- Close flow valve (wellhead).
- Check the drilling and mud logs in an attempt to identify cause.
- See Part 3.1 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Existing or newly mobilized drill rig, logging equipment, cement or casing as required.

Event/Description: Movement of brine between formations: As a well is drilled, multiple concentric strings of casing are installed and cemented. If the cement seal with the outer annulus or inner annuli failed, there will be a pathway for cross contamination of formations, including USDWs.

Severity: Medium

Time of Event: Construction/drilling

Avoidance Measures: Care in well construction particularly with respect to cement placement.

Detection Methods: Monitoring of drilling column pressure, well pressure, annulus pressure, drilling fluid (mud) return flow, and density pressure.

Potential Response Actions: Specific response will be dependent on the type of well (injection or monitoring). In general, the following will be undertaken:

- Stop drilling.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Seal off leaking formation by setting packer.
- Check the monitoring record in an attempt to identify cause.
- Run well logging tools to locate source of cross contamination.
- Identify and implement corrective actions, such as grout injection to seal off zone, re-drill.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Existing or newly mobilized drill rig, logging equipment, cement, or casing as required.

ADVERSE INCIDENTS POTENTIALLY AFFECTING USDWS: INJECTION PERIOD

Event/Description: Loss of Mechanical Integrity: If the cement behind casing or inner annuli failed, there could be a pathway for cross contamination of formations, including USDWs. During injection, CO₂ could travel through geologic formations above the injection and confining zones into a USDW.

Severity: Medium

Time of Event: Operations/injection

Avoidance Measures: Care in well construction particularly with respect to cement placement, including use of casing centralizers.

Detection Methods: Well pressure, annulus pressure, gas flow rate monitoring; well annulus pressure maintenance and monitoring system; continuous monitoring of injection mass flow rate, pressure, temperature, annular pressure, and fluid volume; oxygen-activation tracer logging; noise logging; temperature logging; pressure fall-off testing. See the Testing and Monitoring Plan for specific information.

Potential Response Actions: Specific response will depend on the type of well (injection or monitoring). In general, the following will be undertaken:

- Initiate shutdown plan.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Close flow valve (wellhead).
- Check the monitoring record in an attempt to identify cause.

For Major or Serious Emergency

- Monitor well pressure, temperature, annulus pressure.
- Log hole; check casing and borehole condition.
- Determine cause and extent of failure.
- Grout or install chemical sealant barrier in an adjoining well to block leak.
- Abandon well by completely closing it (seal with cement).
- Drill new well if necessary.
- Identify and implement appropriate remedial actions to repair damage to the well (in consultation with the UIC Program Director).
- If contamination is detected, conduct groundwater remediation as required (in consultation with the UIC Program Director).

For Minor Emergency

- Reset automatic shutdown devices.
- Monitor well pressure, temperature, annulus pressure.
- Verify integrity loss and determine cause and extent of failure.
- Identify and implement corrective actions.
- See Part 3.1 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Existing or newly mobilized drill rig, logging equipment, cement or casing as required.

Event/Description: Migration of CO₂ from injection zone through faults and fractures:

This event could occur as a result of CO₂ migrating through existing, unknown faults or fractures or new, seismically induced faults or fractures.

Severity: Medium

Time of Event: Operations/injection

Avoidance Measures: Extensive geophysical characterization has not identified faults or fractures.

Detection Methods: Early leak-detection monitoring in Above Confining Zone (ACZ) well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan.
- Notify the UIC Program Director within 24 hours, per 40 CFR 146.91(c)(3)
- Assess cause by reviewing monitoring data.
- Conduct geophysical survey in an attempt to locate leaks.
- If warranted, resume injection, but reduce injection pressure by reducing flow rate or inject through additional injection wells.
- Intensify monitoring to determine whether migration continues with continued injection.
- Lower reservoir pressure by removing liquids (water, brine, etc.) from the storage reservoir.
- Intersect the migration with extraction wells in the vicinity of the leak, withdraw and re-inject.
- Lower the reservoir pressure by promoting new pathways to access new volumes or strata in the storage reservoir.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Inject grout or chemical sealant to block the leak.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- See Part 3.2 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Migration of CO₂ from injection zone through undocumented wells:

This event could occur as a result of undocumented wells serving as artificial conduits for fluid migration.

Severity: Medium to high depending upon location

Time of Event: Operations/injection

Avoidance Measures: Drilling records reviews and site walkthroughs were conducted. Only three wells were identified and none penetrate the confining zone.

Detection Methods: Early leak-detection monitoring in ACZ well; evidence of gas/water venting at or near the surface proximate to the undocumented well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess the cause by reviewing monitoring data.
- Conduct a geophysical survey in an attempt to locate migration.
- Repair leaking wells by re-plugging with cement.
- Plug and abandon wells that cannot be repaired.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Install chemical sealant or grout barriers to block leaks.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- See Part 3.2 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Newly mobilized drill rig, logging equipment, cement or casing as required.

Event/Description: Migration of CO₂ from injection zone through failure of the confining zone (loss of containment): This event could occur as a result of CO₂ migrating through a compromised confining zone.

Severity: Medium

Time of Event: Operations/injection

Avoidance Measures: Careful monitoring and control of injection flow and pressure with periodic monitoring well sampling.

Detection Methods: Early leak-detection monitoring in ACZ well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Verify integrity of well bore.
- Proceed to response for migration of CO₂ through loss of mechanical integrity, through faults or fractures, or through undocumented abandoned wells according to location of migration and conduct groundwater remediation as required.
- See Part 3.2 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Monitoring well equipment malfunction: Failure or malfunction of well instrumentation that monitors wellhead pressure, temperature, or annulus pressure could result in false readings. In this event, the reservoir could become over-pressurized, possibly resulting in fractures in the confining zone.

Severity: Low; Possibly Medium if injection is not stopped and results in overpressurization

Time of Event: Operations/ injection

Avoidance Measures: Preventive maintenance of equipment.

Detection Methods: Pressure fall-off testing; monitoring of well pressure, temperature, specific conductivity. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Repair monitoring instrumentation
- If repairs cannot be made within hours, then:
 - Initiate shutdown plan.
 - Repair or replace instrumentation.
 - Review monitoring records.
 - Perform reservoir injection tests to determine whether and where fracturing has occurred.
 - Completely close the well (seal with cement).
 - Drill new well if necessary.
 - Conduct groundwater remediation as required (in consultation with the UIC Program Director).
- See Part 3.6 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical and instrument subcontractors.

Equipment: Newly mobilized drill rig and/or instrument repair truck.

Event/Description: Movement of brine from injection zone: This event could occur as a result of CO₂ migration along existing unknown faults or fractures, seismically induced faults or fractures, or failure of the confining zone (loss of containment).

Severity: Medium

Time of Event: Operations/injection

Avoidance Measures: Careful monitoring and control of injection flow and pressure with periodic monitoring well sampling.

Detection Methods: Early leak-detection monitoring in ACZ well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan.

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess cause by reviewing monitoring data.
- Proceed to response for migration of CO₂ from injection zone through faults or fractures according to location of migration and conduct groundwater remediation as required.
- See Part 3.3 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Seismic event: If a seismic event were to occur inducing movement along faults or fractures, well leakage could occur.

Severity: Low to Medium depending upon quake magnitude and location

Time of Event: Operations/injection

Avoidance Measures: The site is located in a seismically stable region.

Detection Methods: Passive seismic monitoring (microseismicity). See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan to stabilize reservoir system.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Evaluate integrity of storage volume by gas pressure response and monitoring instrumentation.
- If a leak is detected, conduct a geophysical survey to locate new fracture zone.
- If warranted, resume injection but reduce injection pressure by reducing flow rate or inject through additional injection wells.
- Intensify monitoring to determine whether migration is continuing with continued injection.
- Lower reservoir pressure by removing liquids (water, brine, etc.) from the storage reservoir.
- Intersect the migration with extraction wells in the vicinity of the leak, withdraw, and re-inject.
- Lower the reservoir pressure by promoting new pathways to access new volumes or strata in the storage reservoir.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Inject grout or chemical sealant to block leak.
- Extract CO₂ from reservoir, and re-inject in more suitable location.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- Investigate the cause of the seismic event.
 - If the event was induced as a result of injection activities, determine whether any operational changes are needed to reduce the likelihood or magnitude of future events.

- Communicate the investigation and findings to the public (see Part 5).
- See Part 3.4 for details on further response.

Response Personnel: Onsite operations staff, drilling crew, supervising professionals, geotechnical contractors, mechanical contractors, as required.

Equipment: Newly mobilized drill rig, logging equipment, cement or casing, as required.

Event/Description: Groundwater/USDW contamination: If there were a failure of the confining zone, failure of the injection or monitoring well, or if the plume encounters an undocumented AoR well, CO₂ or brine could reach groundwater, requiring remediation.

Severity: Medium to High depending upon location

Time of Event: Operations/injection

Avoidance Measures: The entire CO₂ injection project is focused on preventing escape of CO₂ while sequestering the CO₂. The FutureGen oxy-combustion process incorporates gas-cleaning processes to remove at least 97% of contaminants, including mercury, prior to injection. Trace contaminants that might be entrained in CO₂ leaking into USDWs will pose inconsequential risk to the water quality.

Detection Methods: USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Initiate shutdown plan.
- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess cause by reviewing monitoring data.
- Conduct a geophysical survey in an attempt to locate migration.
- Identify and implement appropriate remedial actions (in consultation with the UIC Program Director). If the leak cannot be located or while pursuing corrective measures for the leak, the following remedies may be considered:
 - Drill wells to intersect accumulations in groundwater, preferably near CO₂ aquifer entrance zones.
 - Extract groundwater contaminated with gaseous or dissolved CO₂ water and treat ex situ.
 - Dissolve mineralized CO₂ (carbonates) in water and extract as a dissolved phase through an extraction well for ex situ air stripping.
 - Extract groundwater with metals mobilized by CO₂ and treat ex situ to remove metals and residual CO₂.
 - Use hydraulic barriers to immobilize and contain contaminants by deploying injection and extraction wells.
 - Deploy in situ chemical or biological treatment technologies to enhance biochemical degradation or stabilization of CO₂-related contaminants.
 - Create a hydraulic barrier by increasing reservoir pressure upstream of a leak.
 - Place grouts or chemical sealant barriers to block leaks.

- Discontinue injection.
- Provide individual water-treatment systems for each water-supply well user. The configuration for each ex situ treatment system will be determined by water chemistry. Applicable treatment technologies include but are not limited to aeration, pH adjustment, ion exchange, oxidizing filter (manganese greensand), membrane filtration, etc.).
- See Parts 3.2 and 3.3 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors, environmental or water-treatment contractors.

Equipment: Water-treatment equipment, new wellhead plumbing to and from water-treatment equipment, reagents for optional in situ treatment, newly mobilized drill rig, logging equipment, cement or casing, as required.

ADVERSE INCIDENTS POTENTIALLY AFFECTING USDWS: POST-INJECTION SITE-CARE PERIOD

Event/Description: Loss of mechanical integrity (monitoring wells): During the post-injection period, CO₂ could travel through a compromised monitoring well into a USDW.

Severity: Medium

Time of Event: Post-injection site care

Avoidance Measures: Care in well construction particularly with respect to cement placement.

Detection Methods: Monitoring of well pressure, temperature, specific conductivity. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

In general, the following will be undertaken:

- Notify the UIC Program Director within 24 hours, per 40 CFR 146.91(c)(3).
- Check the monitoring record in an attempt to identify cause.
- Log hole; check casing and borehole condition.
- Repair annulus seal or replace casing.
- Grout or install chemical sealant barrier in an adjoining well to block leak.
- Abandon well by completely closing it (seal with cement).
- Drill new well if necessary.
- Investigate whether USDW contamination occurred.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- See Part 3.2 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Existing or newly mobilized drill rig, logging equipment, cement or casing as required.

Event/Description: Migration of CO₂ from injection zone through faults and fractures:

This event could occur as a result of CO₂ migrating through existing, unknown faults or fractures or new, seismically induced faults or fractures.

Severity: Medium

Time of Event: Post-injection site care

Avoidance Measures: Extensive geophysical characterization has not identified faults or fractures.

Detection Methods: Early leak-detection monitoring in ACZ well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess cause by reviewing monitoring data.
- Conduct geophysical survey in an attempt to locate leaks.
- Intensify monitoring to determine whether migration continues.
- Lower reservoir pressure by removing liquids (water, brine, etc.) from the storage reservoir.
- Intersect the migration with extraction wells in the vicinity of the leak, withdraw and re-inject.
- Lower the reservoir pressure by promoting new pathways to access new volumes or strata in the storage reservoir.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Inject grout or chemical sealant to block the leak.
- Extract CO₂ from the reservoir, and re-inject in a more suitable location.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- See Parts 3.2 and 3.3 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Migration of CO₂ from injection zone through undocumented wells:

This event could occur as a result of undocumented wells serving as artificial conduits for fluid migration.

Severity: Medium to High depending on location.

Time of Event: Post-injection site care

Avoidance Measures: Drilling records and site walkthroughs were conducted. Only three wells were identified and none penetrate the confining zone.

Detection Methods: Early leak-detection monitoring in ACZ well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess the cause by reviewing monitoring data.
- Conduct a geophysical survey in an attempt to locate migration.
- Locate undocumented well(s).
- Repair leaking wells by re-plugging with cement.
- Repair leaking undocumented functional wells with well-recompletion techniques such as replacing casing and packers or re-cementing annular spaces.
- Plug and abandon wells that cannot be repaired.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Install chemical sealant or grout barriers to block leaks.

- Identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- See Part 3.2 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors.

Equipment: Newly mobilized drill rig, logging equipment, cement or casing as required.

Event/Description: Migration of CO₂ from injection zone through failure of the confining zone (loss of containment): This event could occur as a result of CO₂ migrating through a compromised confining zone.

Severity: Medium

Time of Event: Post-injection site care

Avoidance Measures: Careful monitoring of pressure with periodic monitoring well sampling.

Detection Methods: Early leak-detection monitoring in ACZ well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Verify integrity of well bore.
- Proceed to response for migration of CO₂ through well bore, through faults or fractures, or through undocumented abandoned wells according to location of migration and conduct groundwater remediation as required.
- See Part 3.2 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Monitoring well equipment malfunction: Failure or malfunction of well instrumentation that monitors wellhead pressure, temperature, or annulus pressure could result in false readings. In this event, the reservoir could become over-pressurized, possibly resulting in fractures in the confining zone.

Severity: Low; Possibly Medium if injection is not stopped and results in overpressurization

Time of Event: Post-injection site care

Avoidance Measures: Preventive maintenance of equipment.

Detection Methods: Pressure fall-off testing; monitoring of well pressure, temperature, specific conductivity. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).

- Repair monitoring instrumentation
- If repairs cannot be made within hours, then:
 - Initiate shutdown plan.
 - Repair or replace instrumentation.
 - Review monitoring records.
 - Perform reservoir injection tests to determine whether and where fracturing has occurred.
 - Completely close the well (seal with cement).
 - Drill new well if necessary.
 - Conduct groundwater remediation as required (in consultation with the UIC Program Director).
- See Part 3.6 for details on further response.

Response Personnel: Drilling crew, supervising professionals, geotechnical and instrument subcontractors.

Equipment: Newly mobilized drill rig and/or instrument repair truck.

Event/Description: Movement of brine from injection zone: This event could occur as a result of CO₂ migration along existing unknown faults or fractures, seismically induced faults or fractures, or failure of the confining zone (loss of containment).

Severity: Medium

Time of Event: Post-injection site care

Avoidance Measures: Careful monitoring of injected CO₂ pressure and distribution with periodic monitoring well sampling.

Detection Methods: Early leak-detection monitoring in ACZ well; USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess cause by reviewing monitoring data.
- Proceed to response for migration of CO₂ from injection zone through faults or fractures according to location of migration and conduct groundwater remediation as required.
- See Part 3.2 for details on further response.

Response Personnel: Onsite operating staff, supervising professionals, geophysical consultants.

Equipment: Newly mobilized drill rig, geophysics monitoring trucks.

Event/Description: Seismic event: If a seismic event were to occur inducing movement along faults or fractures, well leakage could occur.

Severity: Low to Medium depending upon quake magnitude and location

Time of Event: Post-injection site care

Avoidance Measures: The site is located in a seismically stable region.

Detection Methods: Passive seismic monitoring (microseismicity). See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Evaluate integrity of storage volume by gas pressure response and monitoring instrumentation.
- If a leak is detected, conduct a geophysical survey to locate new fracture zone.
- Intensify monitoring to determine whether migration is continuing over time.
- Lower reservoir pressure by removing liquids (water, brine, etc.) from the storage reservoir.
- Intersect the migration with extraction wells in the vicinity of the leak, withdraw, and re-inject.
- Lower the reservoir pressure by promoting new pathways to access new volumes or strata in the storage reservoir.
- Create a hydraulic barrier by increasing reservoir pressure upstream of the leak.
- Inject grout or chemical sealant to block leak.
- If contamination is detected, identify and implement appropriate remedial actions (in consultation with the UIC Program Director).
- Investigate the cause of the seismic event.
- Communicate the investigation and findings to the public (see Part 5).
- See Part 3.4 for details on further response.

Response Personnel: Onsite operations staff, drilling crew, supervising professionals, geotechnical contractors, mechanical contractors, as required.

Equipment: Newly mobilized drill rig, logging equipment, cement or casing, as required.

Event/Description: Groundwater/ USDW contamination: If there were a failure of the confining zone, failure of the injection or monitoring well, or if the plume encounters an undocumented AoR well, CO₂ or brine could reach groundwater, requiring remediation.

Severity: Medium to High depending upon location

Time of Event: Post-injection site care

Avoidance Measures: The entire CO₂ injection project is focused on preventing escape of CO₂ while sequestering the CO₂. The FutureGen oxy-combustion process incorporates gas-cleaning processes to remove at least 97% of contaminants, including mercury, prior to injection. Trace contaminants that might be entrained in CO₂ leaking into USDWs will pose inconsequential risk to the water quality.

Detection Methods: USDW aquifer monitoring in USDW well. See the Testing and Monitoring Plan for specific information.

Potential Response Actions:

- Notify the UIC Program Director within 24 hours of the incident, per 40 CFR 146.91(c)(3).
- Assess cause by reviewing monitoring data.
- Conduct a geophysical survey in an attempt to locate migration.
- Identify and implement appropriate remedial actions (in consultation with the UIC Program Director). If the leak cannot be located or while pursuing corrective measures for the leak, the following remedies may be considered:
 - Drill wells to intersect accumulations in groundwater, preferably near CO₂ aquifer entrance zones. Extract groundwater contaminated with gaseous or dissolved CO₂ water and treat ex situ.
 - Dissolve mineralized CO₂ (carbonates) in water and extract as a dissolved phase through an extraction well for ex situ air stripping.
 - Extract groundwater with metals mobilized by CO₂ and treat ex situ to remove metals and residual CO₂.
 - Use hydraulic barriers to immobilize and contain contaminants by deploying injection and extraction wells.
 - Deploy in situ chemical or biological treatment technologies to enhance biochemical degradation or stabilization of CO₂ -related contaminants.
 - Create a hydraulic barrier by increasing reservoir pressure upstream of a leak.
 - Place grouts or chemical sealant barriers to block leaks.
 - Provide individual water-treatment systems for each water-supply well user. The configuration for each ex situ treatment system will be determined by water chemistry. Applicable treatment technologies include but are not limited to aeration, pH adjustment, ion exchange, oxidizing filter, membrane filtration, etc.
- See Parts 3.2 and 3.3 for details on further response actions.

Response Personnel: Drilling crew, supervising professionals, geotechnical subcontractors, environmental or water-treatment contractors.

Equipment: Water-treatment equipment, new wellhead plumbing to and from water-treatment equipment, reagents for optional in situ treatment, newly mobilized drill rig, logging equipment, cement, or casing, as required.

3.1 Potential Response Actions to Loss of Injection Well Integrity

If a well blowout occurs during drilling, the blowout preventer will activate automatically. In the unlikely event of blowout preventer failure, heavy fluid would be injected in an attempt to regain hydrostatic control of the well column. If control could not be achieved, new wells that intersect pressurized accumulations of formation fluid and CO₂ could be drilled and pumped to relieve downhole pressures that are driving the release and cement could be injected to permanently close the well(s).

If a well blowout were to occur during injection operations, injection would be stopped immediately. One or more responses would then be implemented depending on the conditions encountered. The master valves would be closed. The well could be killed or permanently closed by pumping cement or heavy kill fluid down the well bore until the well stops flowing. If the flow continued, a heavier kill fluid could be pumped until the hydrostatic pressure of the fluid

column in the well stopped and contained the flow. If the release were to remain uncontrolled, new wells that intersect pressurized accumulations of formation fluid and CO₂ could be drilled and pumped to relieve downhole pressures that are driving the release.

A slow release of CO₂ could occur with a lesser failure of mechanical integrity for an injection well. Responses to such situations would involve equipment repair, temporary cessation of injection operations, and modification of injection equipment or procedures. If a leak occurred outside the outermost casing of an injection well, due to fractures of a confining formation in the immediate vicinity of the well string, localized application of grout sealant would be among the remedial actions considered. Implementation of such a remedy would entail drilling a new well into the affected area and injecting grout sealant into the formation where the formation geometry and properties facilitate lateral dispersion of the sealant into the compromised zone around the exterior of the CO₂ injection well.

Onsite drilling or operations personnel would correct the leakage, depending on when the leak occurs. Equipment used to correct the leak may involve a workover rig and wire-line tools, pipe, packers, bridge plug, and pressure-control equipment. In the extremely unlikely situation that a new well is required to relieve pressure, well casing, wellhead equipment, cement or mud equipment, and a secondary drill rig would be required.

3.2 Response Actions to Fluid Movement into USDWs

The immediate and primary responses to detection of injection-related fluid migration into any USDW would be similar to the remedies for a release via mechanical failure or confining formation failure: cessation of injection, notification, identification, and location of the source of the release, and implementation of corrective action to seal or stop the release. The location, size of the release, and access to the problem will control the particular course of remedial action. In the improbable event of an impact on water quality within the surficial aquifer system directly affecting water-supply wells, either point of use, withdrawal water treatment, or alternate water-supply remedies would be provided as appropriate.

3.3 Response Actions to Rapid and Unexpected Movement Beyond Modelled Predictions

If a rapid movement of injection-related fluids were detected or inferred outside of where they are predicted to be, the following response actions would be performed:

- Immediately notify the power plant, owner, and other designated project contacts.
- Notify the UIC Program Director within 24 hours of the incident per 40 CFR 146.91(c)(3).
- Project contacts will determine the severity of the event, based on the information available.

For a major or serious emergency:

- Cease injection according to the procedures in the permit.

- Shut in well (close flow valve).
- Communicate with local authorities to initiate evacuation plans, as necessary.
- Monitor injection well conditions to verify well status.
- Determine if there has been a loss of mechanical integrity of injection or monitoring wells.
- Identify and initiate remedial actions.

For a minor emergency:

- Monitor injection and monitoring well conditions to verify well status.
- Determine if there has been a loss of containment in the reservoir.
- Adjust injection rate as necessary to maintain containment in reservoir.

Once the source and pathway of the release were identified, remedial actions appropriate for the situation would be implemented as described above.

3.4 Response Actions to a Seismic Event

A tiered approach and response will be taken based on event magnitude and proximity to the storage site.

After a seismic event has been identified, a decision must be made regarding the level of impact a given event could have on storage site operations, whether a response is required, and what the appropriate response will be. This decision and response framework will consist of an automated event location and magnitude determination, followed by an alert for a technical review in order to reduce the likelihood of false positives.

Identification of events with sufficient magnitude or that are located in a sensitive area (caprock) should be used as input for decisions that guide the adaptive strategy. Seismic events that affect the operations of CO₂ injection can be divided into two groups/tiers: 1) events that create felt seismicity at the surface and may lead to public concern or structural damage, and 2) events not included in group one, but that might indicate failure or impending failure of the caprock. The operational protocol for responding to events in group one (Tier I) will follow a “traffic light” approach (modified after Zoback 2012; National Research Council 2012) that uses three operational states:

1. Green: Continue normal operations unless injection-related seismicity is observed with magnitudes greater than $M = 2$.
2. Yellow: Injection-related seismic events are observed with magnitude $2 < M < 4$. The injection rate will be slowed and the relationship between rate and seismicity will be studied to guide mitigation procedures, including reduced operational flow rates. The FutureGen Alliance will notify the EPA UIC Program Director of any such event within 24 hours providing information on the status of the storage site.
3. Red: Magnitude 4 or greater seismic events are observed that are related to CO₂ injection. Injection operations will stop and an evaluation will be performed to determine the

source and cause of the ground motion. The FutureGen Alliance will notify the EPA UIC Program Director of any such event within 24 hours providing information on the status of the storage site.

Tier II operational responses to an event or collection of events that indicate possible failure of the primary confining zone may include initiation of supplemental adaptive monitoring activities, injection rate reduction in one or more injection laterals, or pressure reduction using brine extraction wells.

3.5 Response Actions to a Natural Disaster

If a natural disaster occurs that affects normal operation of the injection well, the FutureGen Alliance will perform the following response actions:

- Immediately notify the power plant, owner, and other designated project contacts.
- Notify the UIC Program Director within 24 hours of the incident per 40 CFR 146.91(c)(3).
- Project contacts will determine the severity of the event, based on the information available,

For a major or serious emergency:

- Cease injection according to the procedures in the permit.
- Shut in well (close flow valve).
- Communicate with local authorities to initiate evacuation plans, as necessary.
- Monitor injection well conditions to verify well status.
- Determine if there has been a loss of mechanical integrity of injection and monitoring wells.
- Identify and initiate remedial actions.

For a minor emergency:

- Monitor injection well conditions to verify well status.
- Determine if there has been a loss of mechanical integrity of a single barrier in an injection well and/or in any monitoring wells.
- Initiate notification in accordance with permit conditions
- Identify and initiate remedial actions, as needed.

3.6 Response Actions to Monitoring Equipment Failure

If a device malfunctions and requires repair, a backup monitoring scheme will be initiated. This may include temporary use of manual measurements to compensate for non-functioning equipment or the replacement of equipment with spares. Replacement sensors and repair parts will be maintained onsite to facilitate repair.

Part 4: Emergency Contacts

4.1 FutureGen and Local Agency Notification

If a CO₂ release outside of the injection zone were detected, the Emergency Coordinator and Emergency Operations Manager on duty would be notified immediately. The Emergency Coordinator will be responsible for notifying offsite emergency agencies and resources. If the Emergency Coordinator is not available, the Emergency Operations Manager will contact outside emergency response organizations (listed in Table 3) appropriate for the situation. The EPA Region 5 UIC Program Director will also be notified within 24 hours.

Table 3. Outside Emergency Response		
Agency	Location	Phone
Fire	Alexander, IL	911 217-478-3341
Ambulance	Jacksonville, IL	911 217-245-7540
Passavant Area Hospital	Jacksonville, IL	217-245-9541
State Police		217-786-7101
Illinois Emergency Management Agency	Springfield, IL	217-782-7860
Jacksonville/Morgan County Emergency Services & Disaster Agency	Jacksonville, IL	217-479-4616
Sheriff	Jacksonville, IL	217-245-4143

4.2 Injection Operations Staff

Monitoring, control, and routine maintenance of the injection operations at the FutureGen 2.0 storage site in Morgan County will be the responsibility of the Injection Operations Staff. The staff is expected to include the minimum positions as listed in Table 4.

Table 4. Operations Staff Descriptions		
Position	Function	Qualifications
Emergency Coordinator	Responsible for notification of offsite support agencies in accordance with written procedures. Responsible for coordination and overseeing contact with the media.	Trained in the Communications Plan and Emergency Notification Procedures requirements as contained in the ERRP.
Emergency Operations Manager	Serves as the Alliance Emergency Response Manager responsible for the overall management of the Alliance Incident Response Team. Manages facility operations and personnel during an emergency and is responsible for implementation of appropriate emergency procedures and their follow-up.	Trained in the requirements of the ERRP and facility operations.
Senior Geologist/Geophysicist	Responsible for injection operation, maintenance, and monitoring. Lead incident response manager regarding injection and storage zone operation at the facility.	Graduate degree in geology/geophysics with at least 5 years of experience in geologic reservoir dynamics and relevant monitoring interpretation.
Geologist/Geophysicist	Professional associate assisting in operation, maintenance, and monitoring of injection process. Conducts routine data management and interpretation. Assists in implementing response actions, particularly in regard to injection zone integrity.	Undergraduate degree in geophysics or geology with specialization in hydrology/fluid mechanics.

4.3 Agency Notification

Agency emergency response services will also be provided by the Illinois State Geological Survey, Illinois Department of Natural Resources, and U.S. Geological Survey Water Resources for Illinois. In addition to the emergency contact lists, a list of contacts for state agencies having jurisdiction within the AoR is presented in Table 5. At this time, there are no federally recognized Native American Tribes located within the AoR or the State of Illinois (<http://www.ncsl.org/research/state-tribal-institute/list-of-federal-and-state-recognized-tribes.aspx>). If a federally recognized Native American Tribe exists in the AoR or the State of Illinois at the time of a site emergency, it will be notified of the site emergency at that time.

Table 5. Agency Emergency Response			
Agency	Person	Position	Address and Phone
USEPA Region 5	Jeffrey McDonald	UIC Program Contact	Chicago, IL (312) 353-6288
Illinois State Geological Survey	Randall A. Locke, II	Environmental Geochemist and Head Geochemistry Section	Room 387, Natural Resources Building 15 E. Peabody, University of Illinois Champaign, IL 61820 217-333-3866
Illinois Department of Natural Resources	-	Office of Law Enforcement	One Natural Resources Way Springfield, IL 62702 217-785-8407
U.S. Geological Survey Water Resources for Illinois	-		1201 W. University Avenue, Suite 100 Urbana, IL 61801 217-328-8747

Part 5: Emergency Communications Plan

Prior to the start of CO₂ injection operations, the FutureGen Alliance will formally communicate with landowners living adjacent to the storage site to provide information about the nature of the operations, potential risks, and appropriate response approaches under various emergency scenarios.

An emergency contact list will be maintained during the life of the project. In the event of an emergency, the Emergency Coordinator will start the call tree and make sure the appropriate personnel are contacted.

Emergency communications with the public will be handled by the FutureGen Alliance. The Emergency Coordinator is a FutureGen Alliance-designated individual who will coordinate responses to the media.

The FutureGen Alliance will communicate to the public about any event that requires an emergency response to ensure that the public understands what happened and any environmental or safety implications. The amount of information, timing, and communications method(s) will be appropriate to the event, its severity, whether any impacts to drinking water or other environmental resources occurred, any impacts to the surrounding community, and their awareness of the event.

The FutureGen Alliance will describe what happened and the location of any emergency event (e.g., at the injection well or wells; within the AoR; at a monitoring well location), any impacts to the environment or other local resources, how the event was investigated, what responses were taken, and the status of the response. For responses that occur over the long-term (e.g., ongoing cleanups), the FutureGen Alliance will provide periodic updates on the progress of the response action(s).

If a seismic event occurs, the FutureGen Alliance will provide information about whether the event was naturally occurring or induced by the injection; whether any damage to the well or other structures in the area occurred; the investigative process; and what responses, if any, were taken by the FutureGen Alliance or others.

The FutureGen Alliance will also communicate with entities who may need to be informed about or take action in response to the event, including local water systems, CO₂ source(s) and pipeline operators, land owners, and Regional Response Teams (as part of the National Response Team). Response personnel will receive information including but not limited to:

- The location of the injection and monitoring wells (coordinates and directions to the storage site);
- A map of the area including the location of the wells, nearby population centers, and sensitive environments;
- Schematics and diagrams of the facility and the well, including the location of monitoring equipment and emergency shutoffs.

In the event that anyone else is contacted to comment on any situation deemed an “emergency,” the media contact should be directed to the FutureGen Alliance -designated individual, who will oversee all media communications with the public (through either interview, press release, Web posting, or other) in the event of an emergency situation related to the injection project.

Part 6: Plan Review

The FutureGen Alliance will annually review and, as necessary, revise its ERRP. In addition, the FutureGen Alliance will review and, as necessary, revise its ERRP within one year of an AoR reevaluation or within one year after any significant changes to the facility such as the addition of injection or monitoring wells. Any revised plan will be submitted to the EPA UIC Program Director for approval. If, after a review, the FutureGen Alliance determines that no revisions are necessary, the FutureGen Alliance will submit its determination and the basis for such a determination to the EPA UIC Program Director.

Part 7: Staff Training and Exercise Procedures

All operations employees will receive training related to health and safety, operational procedures, and emergency response according to the roles and responsibilities of their work assignments. Initial training will be conducted by, or under the supervision of, a project operations manager or a designated representative. Trainers will be thoroughly familiar with the Operations Plan and ERRP.

Facility personnel will participate in annual training that teaches them to perform their duties in ways that prevent the discharge of CO₂. The training will include familiarization with operating procedures and equipment configurations appropriate to the job assignment, as well as

emergency response procedures, equipment, and instrumentation. New personnel will be instructed before beginning their work.

Refresher training will be conducted at least annually for all operations personnel. Monthly briefings will be provided to operations personnel according to their respective responsibilities and will highlight recent operating incidents, actual experience in operating equipment, and recent storage reservoir monitoring information.

Only personnel who have been properly trained will participate in drilling, construction, operations, and equipment repair at the storage site. A record including the person's name, date of training, and the instructor's signature will be maintained.